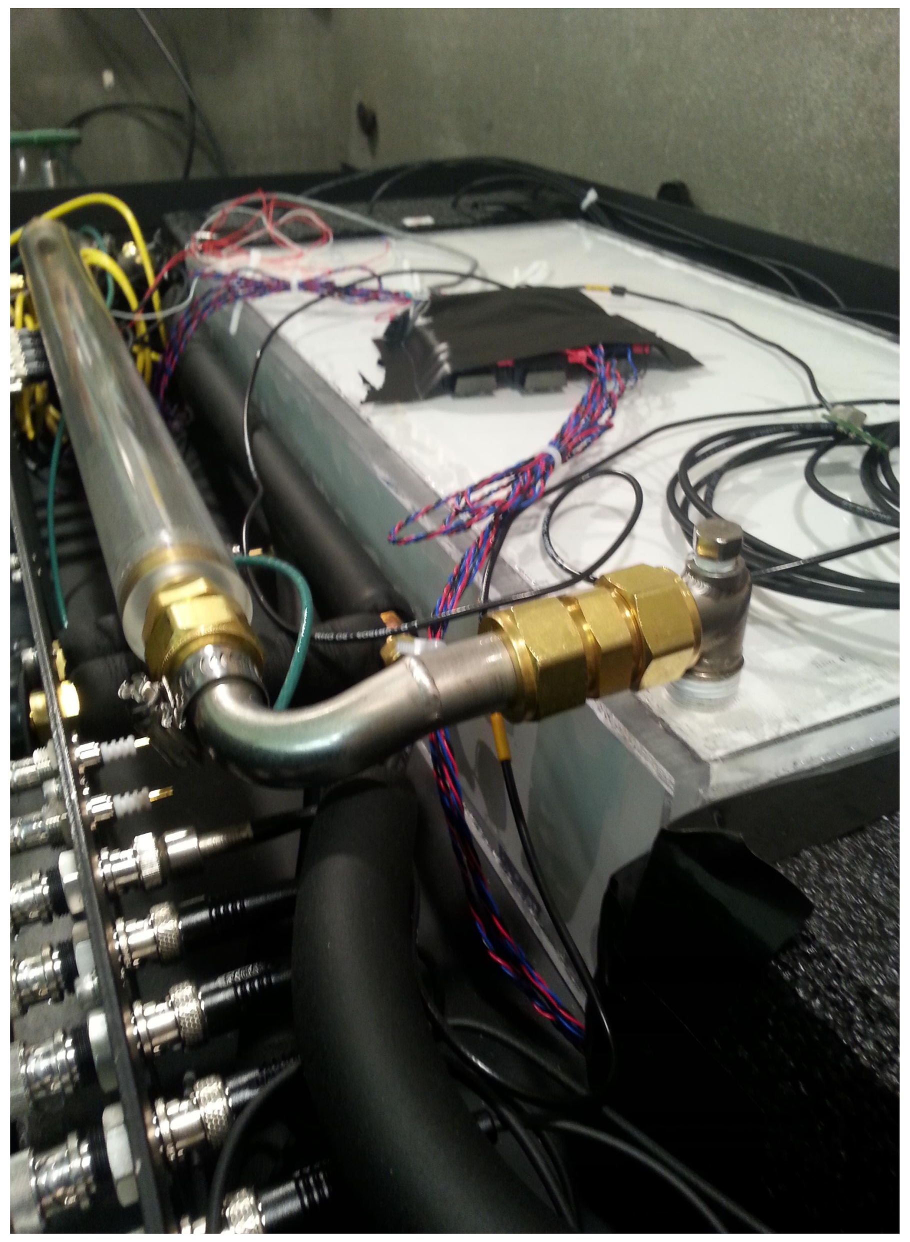
Prototyping of a Neutron Veto for SuperCDMS

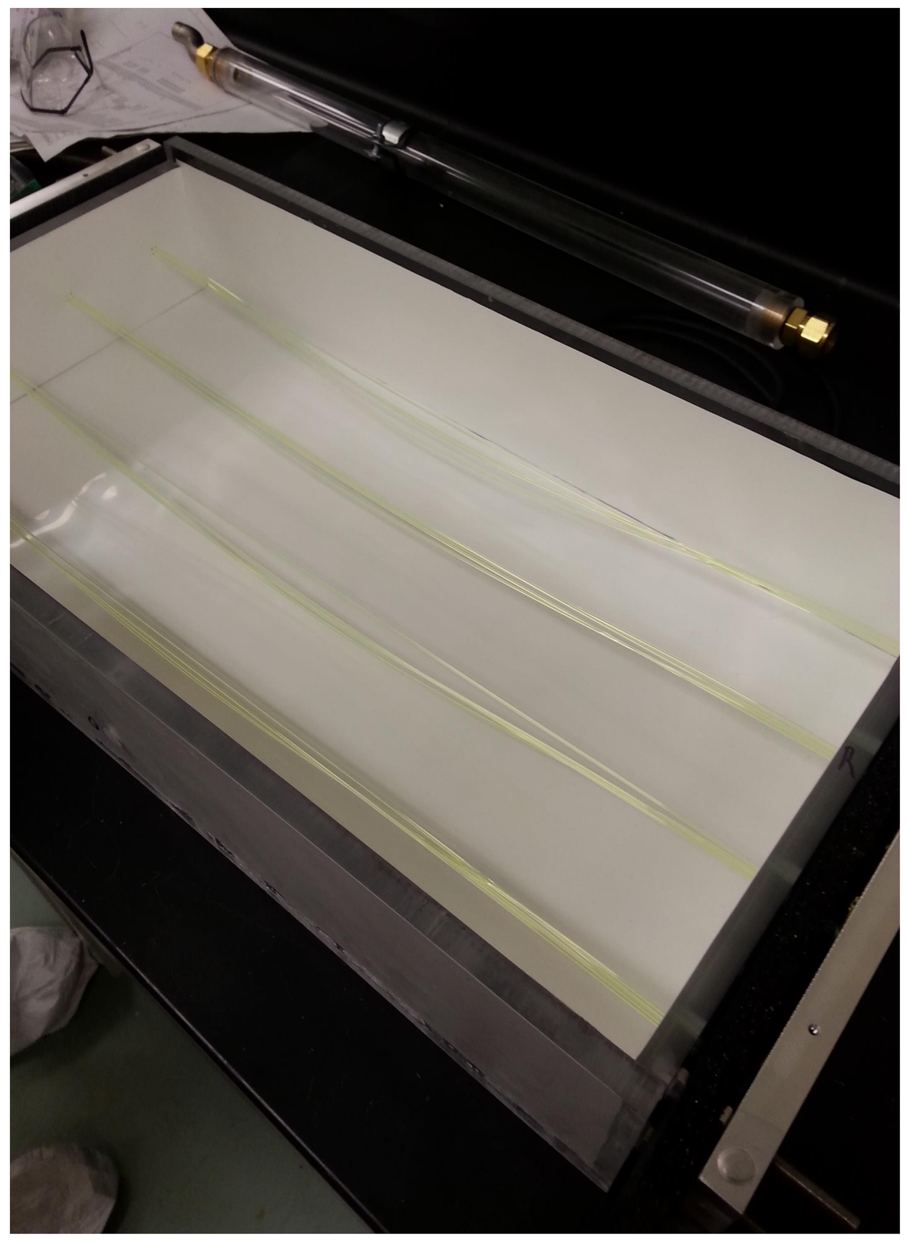
Matthew Bressler

Abstract

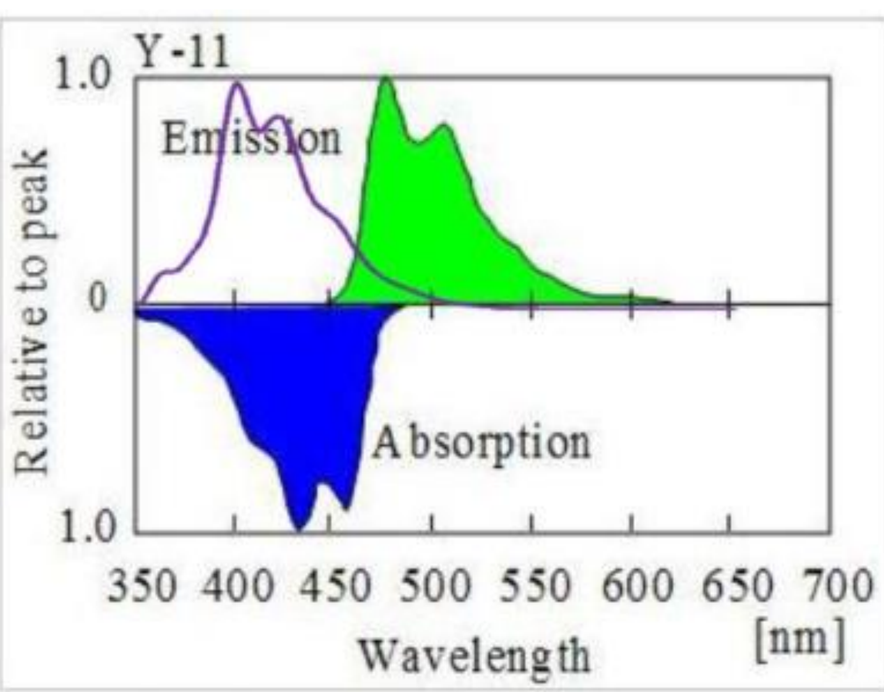
The prototyping studies for the SuperCDMS neutron veto are described. We built a ¼ scale prototype of a single module of the veto that will surround the cryostat. The research consisted of two main goals: the prototyping of the detector box and studying silicon photomultipliers (SiPMs). We determined that 5 minute epoxy does not react adversely with TMB, so it is the best glue to use to adhere reflector to the acrylic box. The ideal scintillation cocktail is 2 g/L PPO and 6.5 mg/L bis-MSB in LAB base. We determined that SiPMs, when exposed to low levels of light, can be approximated as linear. SiPMs exhibit good single photon detection, and their bias voltage can be changed by small amounts to fine-tune the gain. SiPMs are sensitive to temperature changes, so upon cooling their gain will increase and their dark noise will decrease. SiPMs should be operated at low temperatures to reduce noise and decrease the required bias voltage for a given gain.

Detector Prototype



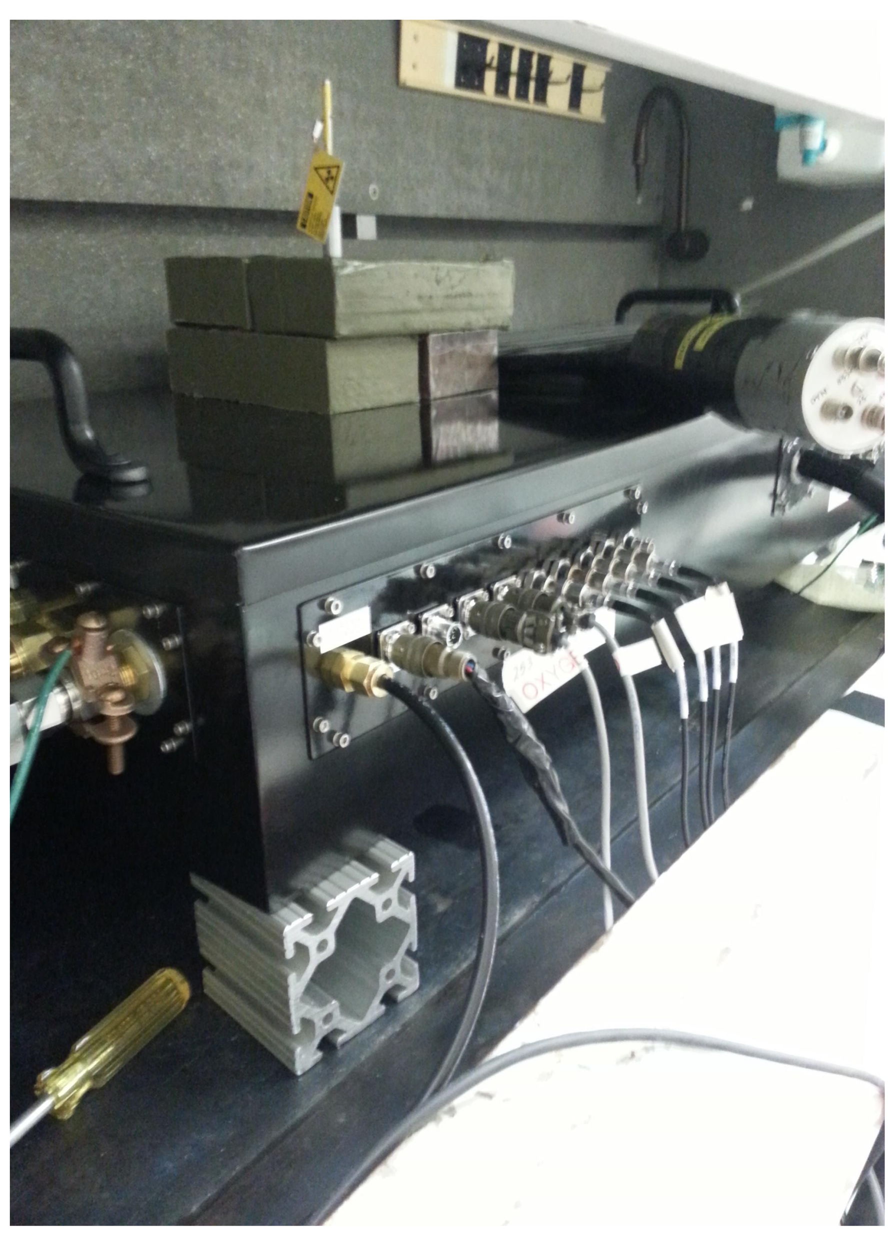


Box Setup: On the left: The white detector box seen inside the secondary containment box, with the cooling lines, expansion volume, foam insulation boxes, and data out cables; this is the final setup. On the right: Before attaching the top of the box and Si photomultipliers, the sixteen wavelength shifting fibers in four groups of four can be seen strung through the box and the cooling endplates.



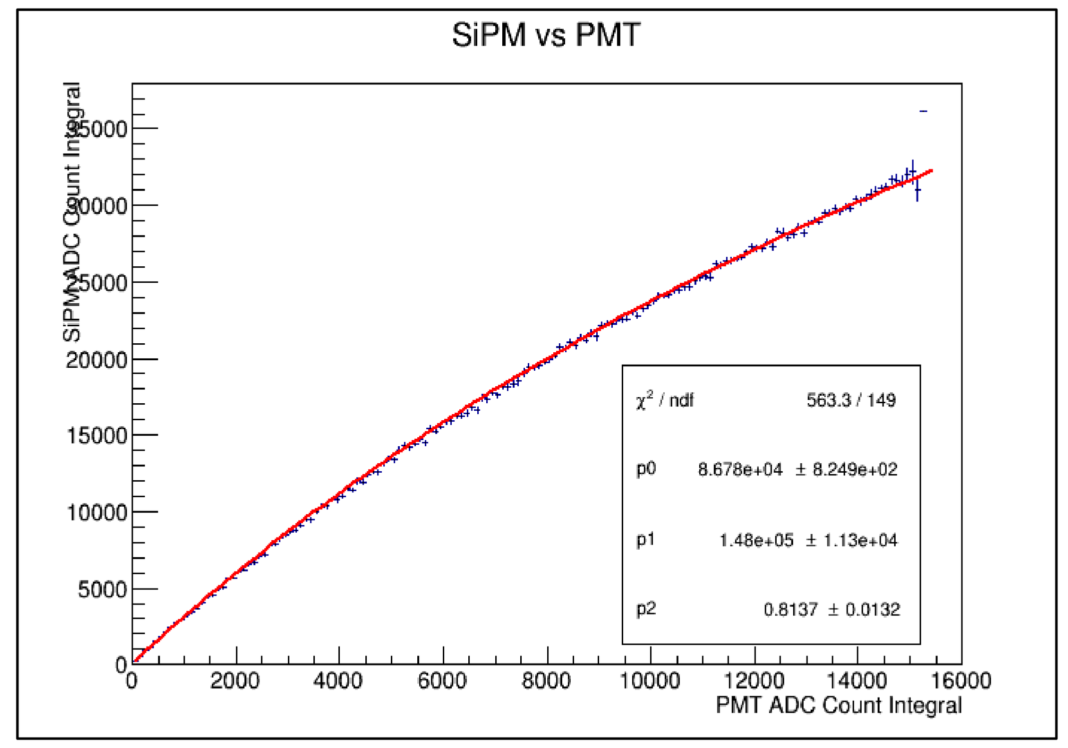
Kuraray Fiber Spectra (filled) with overlaid spectrum of 1:9 solution of Master and Dilute solutions.

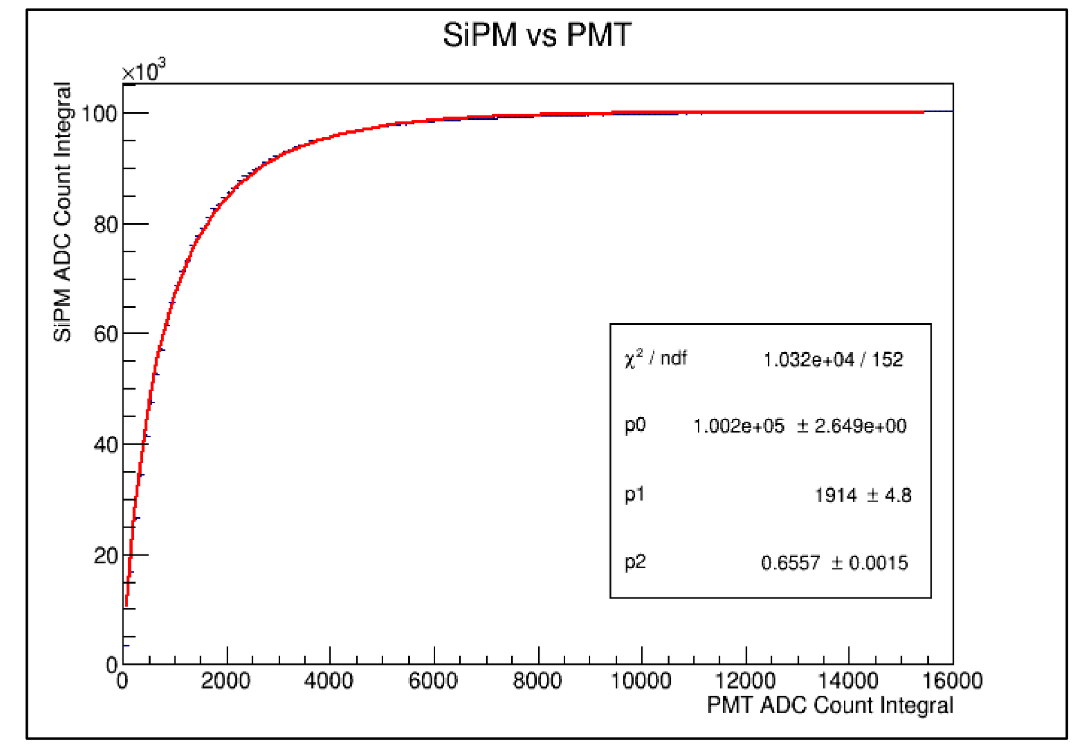
Spectra: The emission spectrum (purple) of 2g/L PPO and 6.5 mg/L bis-MSB in LAB is overlaid on absorption (blue) and emission (green) spectra of the wavelength shifting fibers.



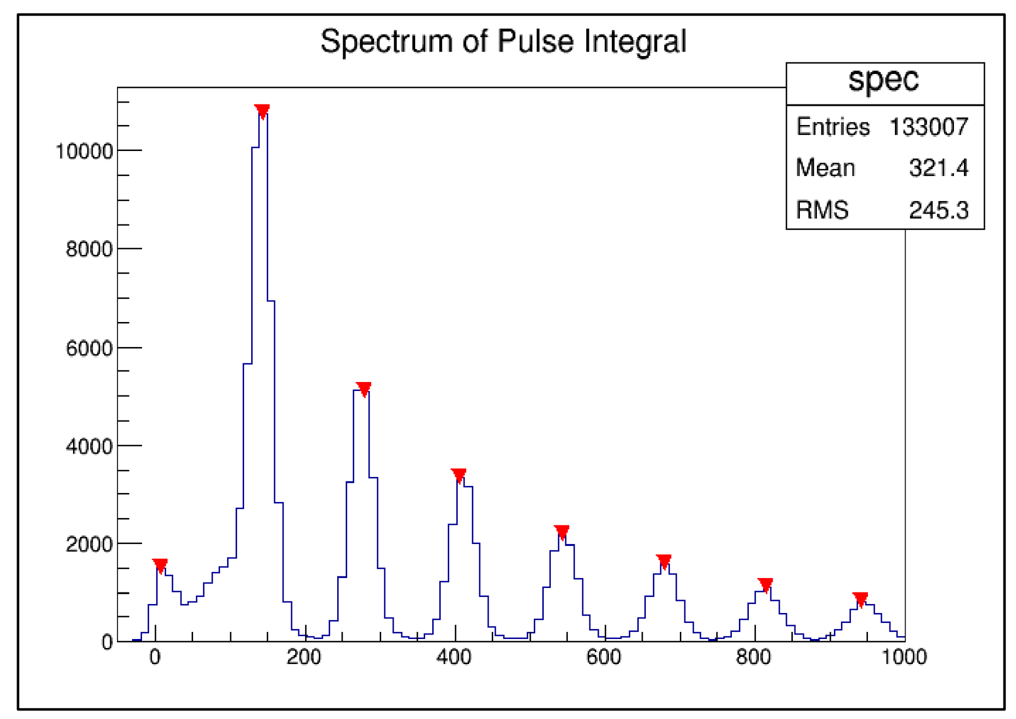
Testing: The prototype is being tested with radiation sources using an internal trigger as well as using a cosmic ray telescope trigger for cosmic ray muons.

Studies of Silicon Photomultipliers

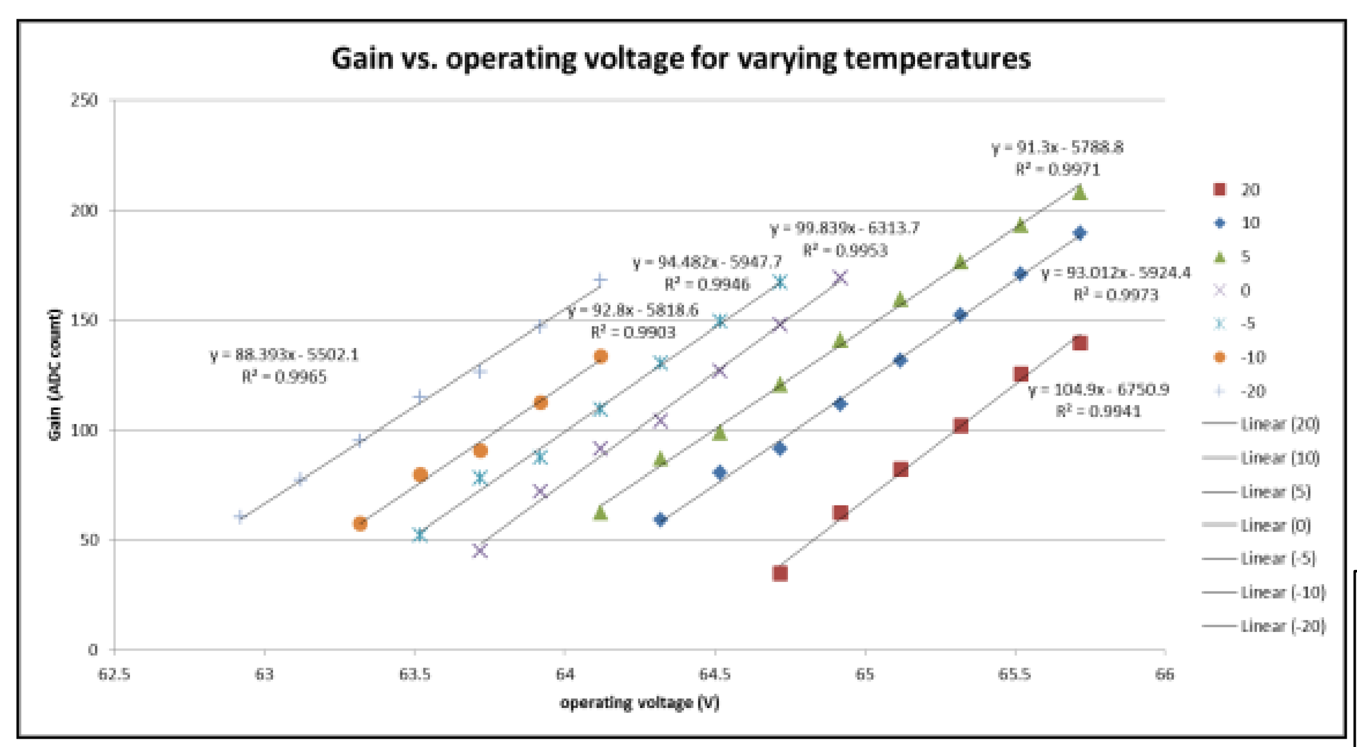




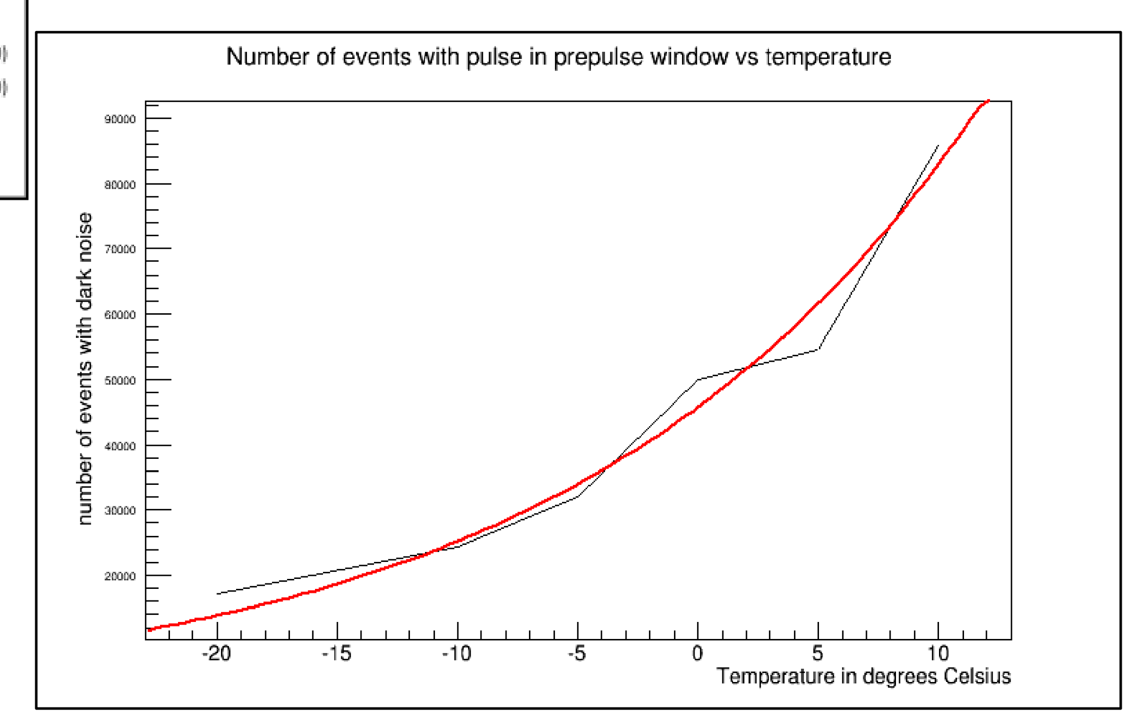
Linearity: SiPM vs. PMT response to low (left) and high (right) levels of light produced by an LED. SiPMs are approximately linear at low levels of light (~50 photons). Saturation effects take over if light levels become too high.



Photon Peaks: SiPMs show well-separated peaks representing numbers of photons. This histogram shows the spectrum of the integrals of the pulse regions of single events. The x axis is in integrated ADC counts. The difference in ADC counts between two adjacent peaks is the gain, plotted below for various temperatures and bias voltages.



Gain Data for Various Temperatures: By choosing a desired gain and temperature, these fits can be used to determine the correct operating voltage for the silicon photomultipliers.



Dark Noise: A program was created to search through the events of a given run and find the number of events in that run with a pulse during the time no LED flash had occured. This number decreases exponentially with temperature.